

**NATIONAL PLAN TO ENHANCE
AVIATION SAFETY THROUGH
HUMAN FACTORS IMPROVEMENTS**

**Clay Foushee
FAA**

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CONTROLLER

PURPOSE

The purpose of this section of the Plan is to establish a development and implementation strategy plan for improving safety and efficiency in the Air Traffic Control (ATC) system. These improvements will be achieved through the proper applications of human factors considerations to the present and future systems.

The program will have four basic goals:

- prepare for the future system through proper hiring and training.
- develop controller work station team concept (managing human errors).
- understand and address the human factors implications of negative system results (NMACs, incursions, etc.).
- define the proper division of responsibilities and interactions between the human and the machine in ATC systems.

PROGRAM ELEMENTS

This plan addresses six program elements which together address the overall purpose. The six program elements are

1. Determine principles of human-centered automation that will enhance aviation safety and the efficiency of the air traffic controller.
2. Provide new and/or enhanced methods and techniques to measure, assess, and improve human performance in the ATC environment.
3. Determine system needs and methods for information transfer between and within controller teams and between controller teams and the cockpit.
4. Determine how new controller work station technology can optimally be applied and integrated to enhance safety and efficiency.
5. Assess training needs and develop improved techniques and strategies for selection, training, and evaluation of controllers.
6. Develop standards, methods, and procedures for the certification and validation of human engineering in the design, testing, and implementation of any hardware or software system element which affects information flow to or from the human.

PROGRAM MANAGEMENT

(Details of program management are yet to be worked out but it appears obvious that to be effective, the program must be managed in such a way as to cross all organizational lines. Attached is a paper entitled "Configuration of the Mind: a concept of Human Factors" which may contain the basic requirements for the management of this program.)

PROGRAM DESCRIPTIONS

1. AUTOMATION

Program Element. - Determine principles of human-centered automation that will enhance aviation safety and the efficiency of the air traffic controller.

Problem. - The proposed introduction of advanced computer-based technology into the controller work environment will be associated with a dramatic change in both the role and expertise expected of the controller. To an increasing degree, the computer will be working from a self generated "plan" to make recommendations to the controller. The controllers ability and willingness to accept these decisions while maintaining responsibility for the separation of aircraft will present major challenges to system designers.

Approach

1. Develop a human centered philosophy of automation by evaluating levels and degrees of automation as well as alternative automation strategies. The human as monitor is one extreme while the machine as monitor is the other.

2. Define the limits to automation tasks. This should include a determination of when an automated system should be limited due to the human's inability to comprehend its actions or to take over where procedures require.

3. In keeping with the proposed level of human responsibility, evaluate the human functions dynamically as automated system planning evolves.
4. Define function allocation and more explicit criteria for assigning tasks, and develop quantitative measures.
5. Conduct scientifically valid simulation studies which measure human performance using various automation philosophies (i.e., kind and level of automation).

Results/Products

1. A methodology for evaluating the effect of alternative levels of automation on overall human/system performance in a real time simulated and real time operational environment
2. Guidelines for determining the optimal role of both the controller and the automation under various conditions
3. Guidelines for warning devices/alerting systems which notify the human of the failure or partial failure of an automated system

2. HUMAN PERFORMANCE

Program Element. - Provide new and/or enhanced methods and techniques to measure, assess, and improve human performance in the ATC environment.

Problem. - The existing body of human factors knowledge, data and methods for assessing and predicting human performance needs to be expanded. Easy to use and predictive workload measurers are not available.

Approach

1. Investigate and identify the human performance limitations at the ATC work station. Realistic human performance expectations (including what can designers realistically expect in human performance, e.g., what is the required time to respond to an external stimulus?) should be developed.
2. Develop improved methods of measuring controller mental state and workload criteria.
3. Define the effects on performance of fatigue, disruptive rest/work cycles, and drugs.
4. Develop fundamental understanding of decision making and means to aid or improve it in aviation.
5. Define team building methodologies for improved ATC work station resource management, including means to support or enhance the decision making process.

Results/Product

1. Provision of basic tools needed to assess potential problem areas and evaluate design.
2. Guidelines for work station design, certification, and operating procedures.
3. Plan for an ATC work station resource management (team building) program.

3. INFORMATION TRANSFER/CONTROLLER-PILOT INTERFACE

Program Element. - Determine system needs and methods for information transfer between and within controller teams and between controller teams and the cockpit.

Problem. - The information requirements of controllers and flight crews in an increasingly complex aviation system must be specified, and methods developed for the transfer, management, and integration of this information in ways which reduce the chance of accident due to human error.

Approach. - The sources and types of information available to and needed by the controller and flight crew will be identified, classified and prioritized. Various data entry and display methods will be evaluated in part-task studies prior to being integrated and validated in full mission simulations and/or operational evaluations.

Results/Product

1. Prioritized inventory of total information available at the work station
2. Guidelines for information management

4. CONTROLS AND DISPLAYS

Program Element. - Determine how new controller work station technology can optimally be applied and integrated to enhance safety and efficiency.

Problem. - Continued engineering development has, and will continue to provide a technological base to enhance system safety and increase productivity. Methods of displaying, controlling, and integrating data for input to and to accept output from the controller must be further developed to assure proper application.

Approach. - On an ongoing basis, assess the ability of new technology displays and input devices to enhance the man-machine relationship. As appropriate, develop projects to

1. Develop new display technology. This includes new methods (e.g. 3D displays), new materials and color enhancements.
2. Improve and standardize ATC display formats, symbology, and annunciations.
3. Develop data transfer systems that can exchange data between the aircraft and ground in a timely manner.
4. Explore the use of touch panel inputs as well as voice recognition.
5. Apply Artificial Intelligence and expert systems into the ATC work station. Fault analysis and appropriate display to controller should be included.

Results/Product

1. Fundamental understanding of displays for information transfer
2. Guidelines for design and certification of ATC automation and display systems
3. Systems to improve the decision making process

5. SELECTION AND TRAINING

Program Element. - Assess training needs and develop improved techniques and strategies for selection, training, and evaluation of controllers.

Problem. - Current hiring, training, and qualification requirements do not necessarily take into account the operational environment with new automation capabilities in the ATC work station and the new training techniques available. For example, concern has been expressed about the effects of automation on the controller's traditional skills.

Approach

1. Review fundamental training requirements and assess their effectiveness in today's and tomorrow's ATC system.
2. Assess the efficacy of ATC work station resource management training from the perspectives of the present and future needs.

3. Study the types of training programs which can be developed and/or utilized to reduce the causal factors in instances of negative system results.
4. Review controller selection criteria with a view towards appropriate staffing for future systems.
6. Consider the advantages and disadvantages of ab-initio training.

Results/Product

1. Specific human factors audio/visual and CBI training criteria.
2. Human factors training programs for ATC work station resource management (team building).
3. Specifications of training program characteristics which lead to enhanced safety and productivity in the present system and future systems.
4. Definition of a "potential controller" profile and techniques for ascertaining its degree in an applicant.

6.CERTIFICATION

Program Element. - Develop standards, methods, and procedures for the certification and validation of human engineering in the design, testing, and implementation of any hardware or software system element which affects information flow to or from the human.

Problem. - The current FAA process does not adequately stress the importance of and the corresponding need for well founded human factors technology to be applied throughout the initial design stage of new or modified ATC system elements. Nor does the current process provide sufficient procedures for certification of the appropriateness of the input/output of data to/from the human. Nor are there procedures for certifying task assignments and the associated information requirements relative to the human.

Approach

1. Develop new certification standards and the means to assess the human interface with the ATC work stations. Means will be developed to allow evaluation of the effects of the introduction of new systems in the controller work station. Standards will include issues relating to the intermixing of old and new systems as well as transition strategies.

2. Develop standards which assure that human factors considerations are properly incorporated in the existing configuration management process.

Results/Product. - Recommended additions to the existing configuration management system which require appropriate human factors consideration for any new or changed system element which affects the human input, output, or data processing.

CONFIGURATION MANAGEMENT OF THE MIND:

A Concept of Human Factors

We in the FAA have been wrestling for a long time with the concept of Human Factors. We write about it; we study it; we agonize over it, but we can't quite seem to come to grips with it. I submit that while all that has been done, is being done, and will be done is important and necessary, it is all for naught because we continually overlook one key element - application. There exists in the FAA no vehicle whereby the knowledge and experience of the experts in the fields (truly there is a multiplicity of disciplines involved) are brought to bear on the requirements definition, acquisition and implementation process.

This paper proposes a concept which, if implemented as an element of a total FAA Human Factors program, would insure the delivery of far superior products to the controller in the field.

BASIC ASSUMPTIONS

The concept under discussion here makes several basic assumptions. It would be impossible for the concept to be understood, much less accepted, without an acceptance of these assumptions:

- the human is one element in a very complex ATC system of many elements
- a major consideration in controller Human Factors is one of information flow - from the machine to the controller and from the controller to the machine
- the controller has two input sources - ears and eyes
- the controller has two output sources - voice and touch
- each I/O source is unique in its capabilities and its limitations (sight requires direction, touch requires proximity, etc.)
- the human mind processes different data types in different ways; ergo, the form in which a datum type is presented is of extreme importance (properly design allows for pre-processing external to the human.

CURRENT FALLACY

The time honored approach to human factors within the FAA has been: "Ask the user what he wants; he knows best." Often a preliminary step is taken in which a computer display expert or an engineering expert will offer a choice of two or three options for the user to select from. These choices are usually very sound computer display or engineering options, but are they sound human factors options? Another common preliminary step in the name of human factors is to study the new hardware from an ergonomics perspective. These studies will lead to either recommendations or a report (or both) but never to requirements.

The bottom line is that all elements of the system conform to requirements developed and approved by experts in the field except for the most complex system element - the human. And why is this? Simply because all other elements of the system are under configuration management except the human. Also, the transfer of data between elements is designed and controlled by Interface Control Documents (ICDs) but no such vehicle exists for data transfer to or from the human.

THE SOLUTION

A system must be created along with the enabling support structure which will configuration manage the human mind. As is the case with any other configuration managed system element, the supporting structure must have the capability and authority to influence the design, acquisition and implementation of any new or modified hardware, software or procedure which causes a change in the data flow to or from the human. Equally important is the capability and authority over anything which would change the way in which the human processes data.

